CAT® Lift Trucks

Service Manual

6D16 Diesel Engine

DP80	**T32B-00011-up**
DP90	**T32B-50001-up**
DP100	**3DP-00001-up**
DP115	**4DP-00001-up**
DP135	**5DP-00001-up**
DP150	**6DP-00011-up**

For use with Chassis Service Manual. **99709-68130**

6D16

diesel engine

Shop Manual

(for industrial use)

FOREWORD

This Shop Manual is published for the information and guidance of personnel responsible for maintenance of 6D16 diesel engine, and includes procedures for adjustment and maintenance services.
We earnestly look forward to seeing that this manual is made full use of in order to perform correct service with no wastage.

For more details, please consult your nearest authorized Cat™ dealer or distributor.
Kindly note that the specifications and maintenance service figures are subject to change without prior notice in line with improvement which will be effected from time to time in the future.

Applicable models
6D16
6D16-TLE

GROUP INDEX

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Pub. No. 99709-68130

HOW TO READ THIS MANUAL

How This Manual Is Compiled

- This manual is compiled by classifying various systems into certain groups.
- Each group contains specifications; troubleshooting; maintenance service standards; ❶ tightening torque; 🔏 lubricant, fluid and sealant; 🔧 special tools; and service procedure.
- Page enumeration is independent by every group where first page is always 1.

Group No.	Group denomination	Contents
00	General	General specifications, engine No. and name plate, precautions for maintenance operations, table of standard tightening torques
11	Engine	Engine body
12	Lubrication	Lubrication system
13	Fuel and engine control	Fuel system
14	Cooling	Cooling system
15	Intake and exhaust	Intake and exhaust system, intercooler
54	Electrical system	Alternator, starter, preheating system, engine start system, automatic stop system
61	Special equipment	Air compressor

General Explanation of This Manual

● **Specifications**

Particulars relative to maintenance service are made.

● **Structure and operation**

(1) Regarding conventional equipment, descriptions are made in brief.

(2) Regarding new equipment, descriptions of system and operating condition are made in detail.

● **Troubleshooting**

Symptoms of troubles and possible causes are described comparatively.

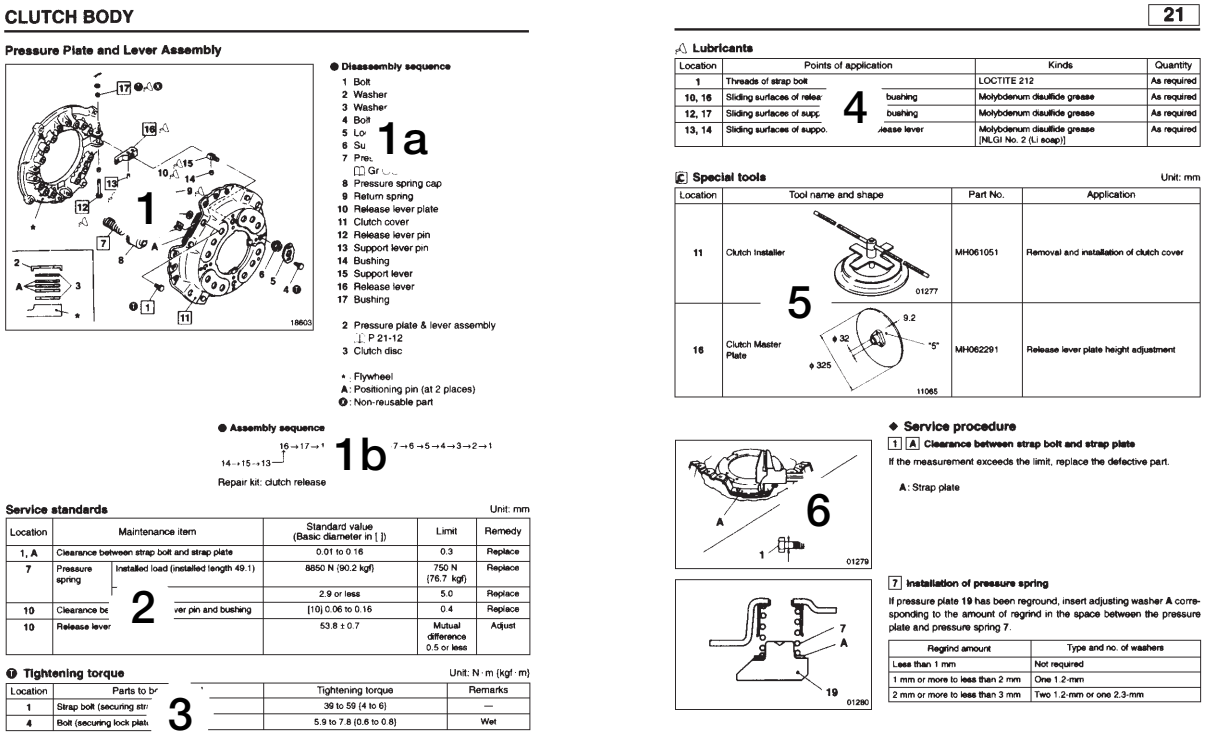
● **Inspection and adjustment mounted in vehicle**

Descriptions are made regarding inspection and adjustment of units mounted in vehicle.

● **Service procedure**

In principle, an explanation is given at the spread title page so that the service procedure can be understood. Servicing points are explained as a supplementary explanation.

Regarding the design of this manual

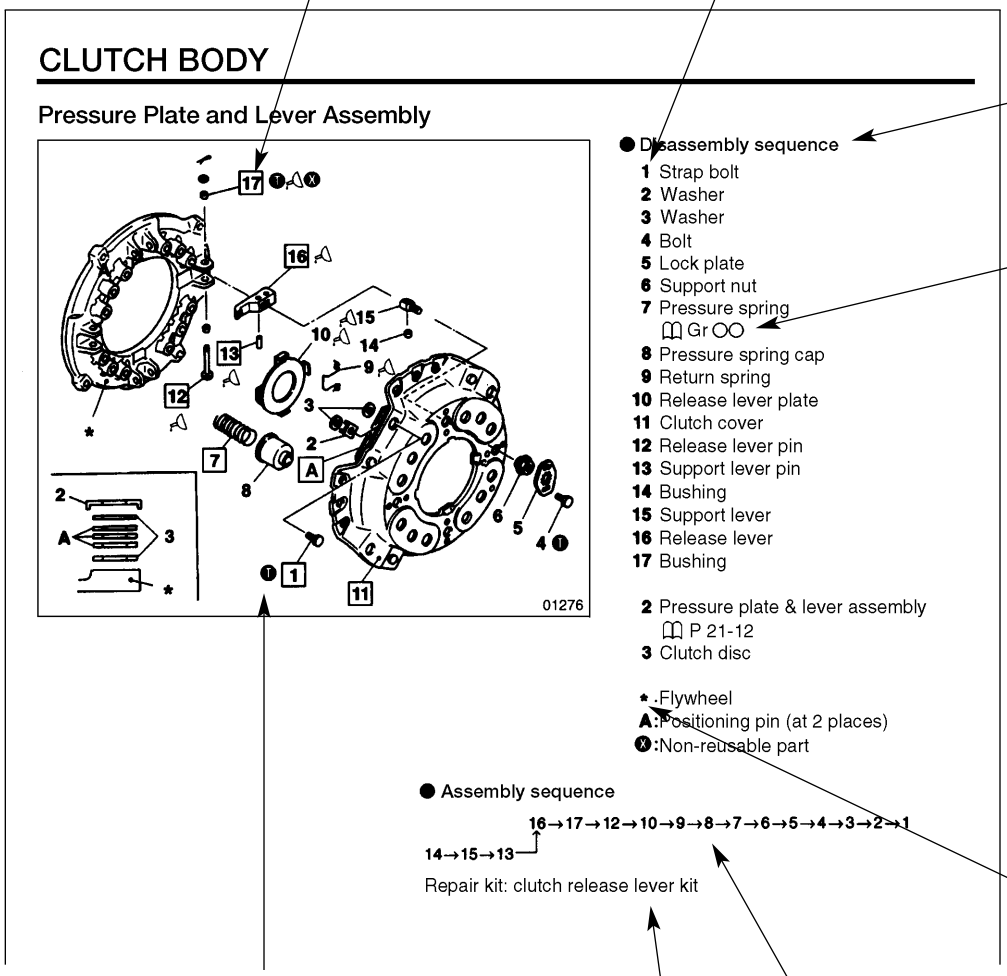


1. ..... Illustration for disassembly and assembly or removal and installation: 3-D exploded view of component parts is displayed.
   1a. ..... Names of parts show an example of the disassembly (removal) sequence.
   1b. ..... When the assembly (installation) sequence differs from the disassembly (removal) sequence, an example of the assembly (installation) sequence is shown.
2. ..... Service standards are shown collectively, classified by location.
3. ..... Tightening torques are shown collectively, classified by location.
4. ..... Points of lubricant, fluid and sealant application are shown collectively, classified by location.
5. ..... Special tools to be used are shown collectively, classified by location.
6. ..... When it is considered hard to understand the service procedure, just by the foregoing description, a supplementary description of the service procedure is given.

1. Illustration for disassembly and assembly or removal and installation

This shows that the appropriate service procedure is described in the text.

This shows the key No. of the part. In the text, this No. is referred to uniformly throughout.



This shows an example of the disassembly (removal) sequence.

This shows that the service procedure is described in another section.

- P.○○-○○ : shows reference page within the same group.
- Gr○○ : shows reference group within the same book.

No service procedure is referred to in this section, but the item can be an objective of various procedures.

This is shown when the assembly (installation) sequence is not the reverse of the disassembly (removal) sequence.

This shows that a repair kit is available.

Meaning of symbols

- T : shows that the tightening torque is specified.
- : shows that application of lubricant, fluid or sealant is required.
- X : shows that the part should not be reused.

2. Service standards table

Only the relevant service standards are shown.

Service standards

Unit: mm (in.)

Location	Maintenance item		Standard value	Limit	Remedy
1, 11	Clearance between strap bolt and strap plate		0.01 to 0.16 (0.0039 to 0.0629)	0.3 (0.0118)	Replace
7	Pressure spring	Installed load (Installed length 49.1)	835 N (85 kgf) [187.7 lbf]	710 N (72.3 kgf) [159.6 lbf]	Replace
		Tilt	2.9 (1.1417) or less	5.0 (0.197)	Replace

This shows the key No. of the relevant part.

3. Tightening torque table

This shows specified tightening torque.

❶ Tightening torques

Unit: N·m (kgf·m) [lbf·ft]

Location	Parts to be tightened	Tightening torque	Remarks
1	Strap bolts (Strap bolt mounting)	39 to 59 (4 to 6) [28.8 to 43.5]	–
4	Bolt (Lock plate mounting)	5.9 to 7.8 (0.6 to 0.8) [4.3 to 10.5]	Wet

This shows the key No. of the relevant part.

This shows that the item is to be tightened wet.

4. Lubricants and sealant table

Only the relevant lubricants and sealant are shown.

This shows the application point.

Lubricants and sealant

Location	Points of application	Kinds	Quantity
1	Thread area of bolt	LOCTITE 272	As required
10, 16	Friction surfaces of release lever plate and release lever	Molybdenum disulfide grease [NLGI No. 2 (Li soap)]	As required

This shows the key No. of the relevant part.

This shows the specified brand.

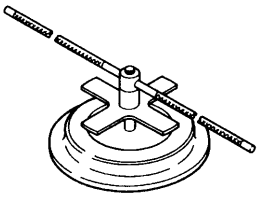
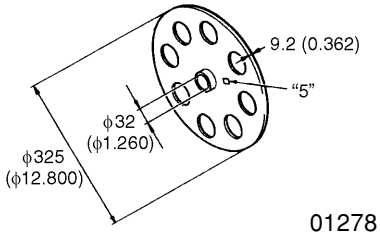
5. Special tools table

Only the relevant special tools are shown.

Purpose of special tools is shown.

Special tools

Unit: mm (in.)

Location	Tool name and shape	Part No.	Application
11	Clutch installer  01277	MH061051	Removal and installation of clutch cover
16	Master plate  01278	MH062291	Adjust release lever heights

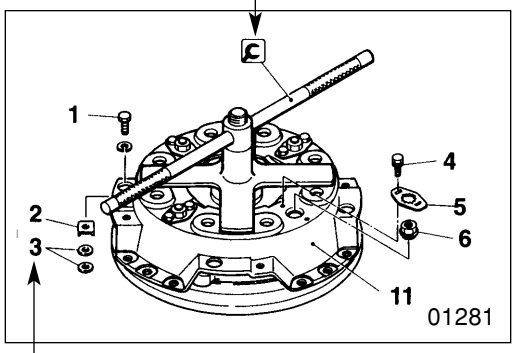
This shows the key No. of the relevant part.

Quote this number when placing an order for the part.

6. Service procedure

This indicates a special service tool.

This shows the key No. of the relevant part.



01281

11 Removal and installation of clutch cover

- Depress pressure spring **7** using clutch installer, then remove the following parts:
  Strap bolt **1**, washer **2**, washer **3**, bolt **4**, lock plate **5**, support nut **6**
- Loosen the clutch installer gradually, then remove clutch cover **11** when the pressure spring is fully released.
- For installation, follow the removal sequence in reverse.

The key No. referred to in the text is always the same as the key No. shown in the illustration.

Servicing procedures of disassembly (removal), assembly (installation), inspection, adjustment, etc. are shown collectively.

Terms and Units

The terms and units in this manual are defined as follows.

- This service manual contains important cautionary instructions and supplementary information under the following four headings which identify the nature of the instructions and information:

DANGER ⚠ — Precautions that should be taken in handling potentially dangerous substances such as battery fluid and coolant additives.

WARNING ⚠ — Precautionary instructions, which, if not observed, could result in serious injury or death.

CAUTION ⚠ — Precautionary instructions, which, if not observed, could result in damage to or destruction of equipment or parts.

NOTE — Suggestions or supplementary information for more efficient use of equipment or a better understanding.

- **Front and rear**

The terms “front” is the fan side and “rear” the flywheels side of the engine.

- **Left and right**

The terms “right” and “left” shall be used to indicate the side as viewed from the flywheel side of the engine.

- **Terms of service standards**

(1) Standard value
Standard value dimensions in designs indicating: the design dimensions of individual parts, the standard clearance between two parts when assembled, and the standard value for an assembly part, as the case may be. The figure in [ ] is the basic diameter.

(2) Limit
When the value of a part exceeds this, it is no longer serviceable in respect of performance and strength and must be replaced or repaired.

- **Tightening torque**

Excessive or insufficient tightening torque has particular importance in respect of performance. Accordingly, tightening torque is specified in locations that are to be tightened.
Where there is no specified figure for tightening torque, follow the table covering standard tightening torques.
When the item is to be tightened in a wet state, wet is indicated. Where there is no indication, read it as dry, and tighten at specified torque.

- **Unit**

Length, weight, surface area and capacity are in SI units with foot-pound units are given in brackets.
Tightening torques and other parameters are given in SI units with metric and foot-pound units added in brackets ( ) and [ ].

Example: 390 N·m (40 kgf·m) [289 lbf·ft]
- 390 N·m — SI unit
- (40 kgf·m) — Metric unit
- [289 lbf·ft] — Foot-pound unit

Temperatures are given in degrees Celsius with degrees Fahrenheit given brackets.
For the conversion into the foot-pound system, refer to the following conversion table.

Unit		SI unit {metric unit}	Conversion factor
Force		N {kgf}	9.80665 N {1 kgf}
Moment of force		N·m {kgf·m}	9.80665 N·m {1 kgf·m}
Pressure	Positive pressure	kPa {kgf/cm^2}	98.0665 kPa {1 kgf/cm^2}
	Vacuum pressure	kPa {mmHg}	0.133322 kPa {1 mmHg}
		Pa {mmH_2O}	9.80665 Pa {1 mmH_2O}
Volume		dm^3 {L}	1 dm^3 {1 L}
Power		kW {PS}	0.7355 kW {1 PS}
Heat quantity		J {kcal}	4186.05 J {1 kcal}
Heat flow		W {kcal/h}	1.16279 W {1 kcal/h}
Angle		°	–
Temperature		°C	–
Electric current		A	–
Voltage		V	–
Resistance		Ω	–
Electric power		W	–

Unit	SI unit	Foot-pound unit	Conversion rate
Force	N (Newton)	lbf	1 N = 0.2248 lbf
Moment of force	N·m	ft.lbs	1 N·m = 0.7375 ft.lbs
Pressure	kPa (kilopascal)	psi	1 kPa = 0.145 psi 1 kPa = 0.2953 in. Hg
Volume	L	gal.	1 L = 0.2642 gal. (U.S.) 1 L = 0.220 gal. (Imp.)
	cm^3	oz	1 cm^3 = 0.033814 oz (U.S.) 1 cm^3 = 0.035195 oz (Imp.)
	cm^3	cu.in.	1 cm^3 = 0.061023 cu.in.
Power	kW (kilowatt)	PS	1 kW = 1.3596 PS
Temperature	°C	°F	t°C = (1.8t°C + 32)°F
Mass quantity of matter	kg	lb	1 kg = 2.2046 lb
	g	oz	1 g = 0.035274 oz
Dimension	m	ft.	1 m = 3.2808 ft.
	mm	in.	1 mm = 0.03937 in.

GENERAL SPECIFICATIONS

Item		Specifications	
Engine model		6D16	6D16-TLE
Type		6-cylinder in-line, water-cooled 4-cycle diesel	
Combustion chamber type		Direct injection type	
Valve mechanism		Overhead valve (OHV) type	
Bore × Stroke	mm (in.)	118 × 115 (4.65 × 4.53)	
Total displacement	cc (cu. in.)	7545 (460.4)	
Compression ratio		17.5	
Empty mass	kg (lb)*	500 (1.102)	560

* Empty mass as measured according to Mitsubishi Motors Corporation standard.

Engine Outputs Classified By Application

Application \ Engine model		6D16	6D16-TLE	
			Middle-speed specification	High-speed specification
Intermittent rated output	kW (HP)	71 (95)/1500 85 (114)/1800 93 (125)/2000 101 (135)/2200 111 (149)/2500 120 (161)/2800	106 (142)/1500 123 (165)/1800 131 (176)/2000 140 (188)/2200	101 (136)/1500 121 (163)/1800 131 (175)/2000 139 (186)/2200 147 (197)/2500 151 (203)/2800
Coutinuous rated output	kW (HP)	65 (87)/1500 77 (103)/1800 84 (113)/2000 93 (125)/2200 101 (135)/2500 110 (147)/2800	96 (129)/1500 111 (149)/1800 119 (160)/2000 127 (170)/2200	92 (123)/1500 110 (148)/1800 118 (158)/2000 125 (168)/2200 133 (178)/2500 137 (184)/2800

NOTE

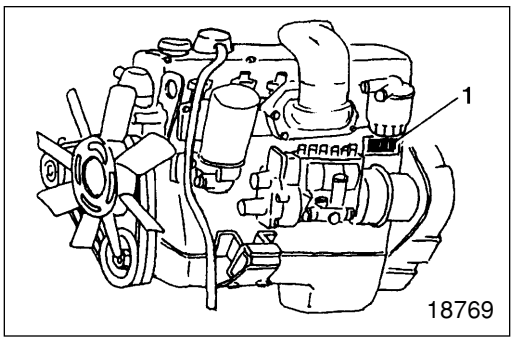
1. The output (SAE, gross) is corrected to standard ambient conditions based on SAE J1349.

2. The continuous rated output allows 10% (one hour) overload operation.

ENGINE NUMBER AND NAME PLATE

The serial number for engine is assigned to the respective engine in manufacturing sequence: every engine has its own number. This number is required for incidental inspection of the engine. Please do not fail to mention this number to the dealers when ordering spare parts.

Engine Number

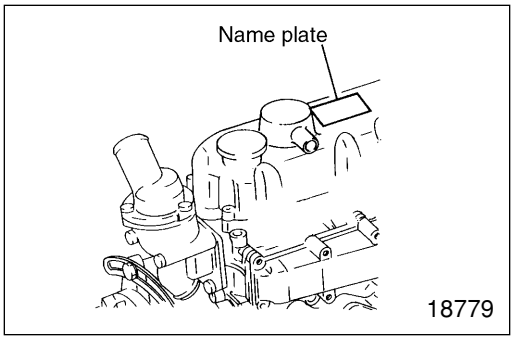


Engine number **1** is punch-marked on the left of the crankcase.

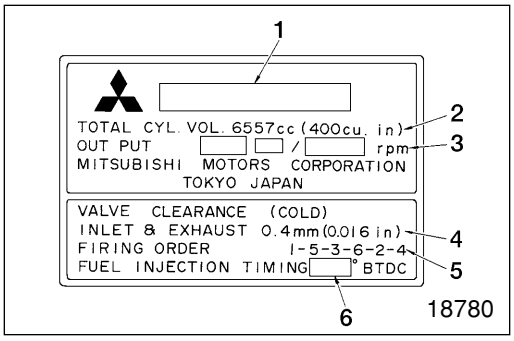
Example: 6D16–□□□□□□

- 6D16 – Engine model
- □□□□□□ – Engine number

Name Plate



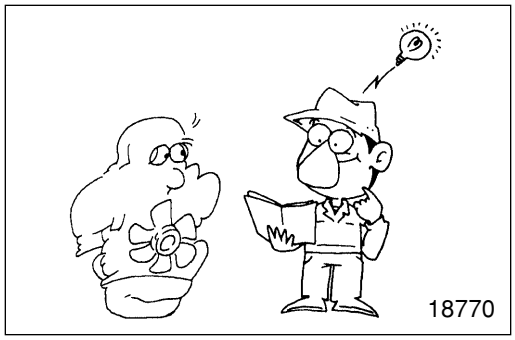
The name plate is attached to the portion shown in the illustration, and indicate the following items.



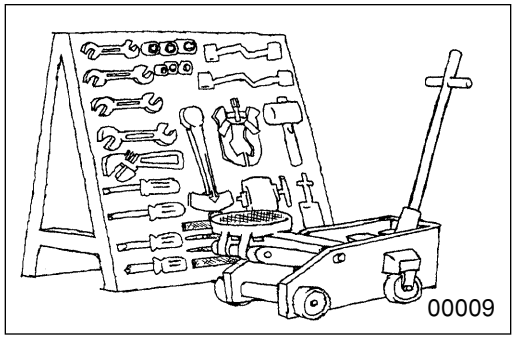
1. Engine model
2. Total displacement
3. Maximum output
4. Valve clearance
5. Firing order
6. Fuel injection timing

PRECAUTIONS FOR MAINTENANCE OPERATION

In order to determine the condition of the vehicle adequately, attend the vehicle beforehand to find and keep record of the accumulated mileage, operating condition, what the customer's demand is, and other information that may be necessary.
Prepare the steps to be taken and perform efficient and wasteless maintenance procedure.



Determine where the fault exists and check for the cause to see whether removal or disassembly of the part is necessary. Then follow the procedure specified by this manual.

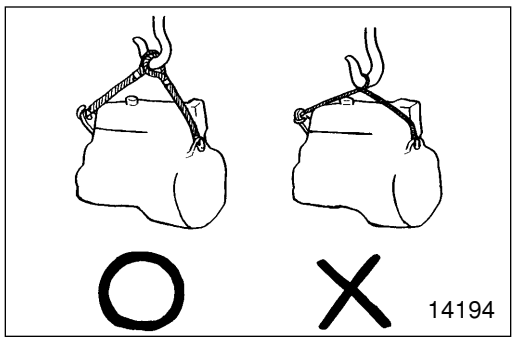


Perform maintenance work at a level area.
Prepare the following.

- Prepare general and special tools necessary for the maintenance work.

WARNING ⚠

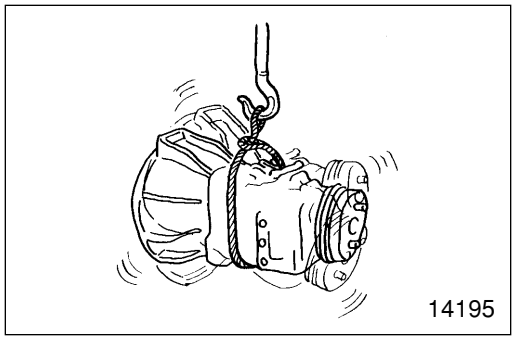
Do not attempt to use tools other than special tools where use of special tools is specified in this manual. This will avoid injury or damage.



Pay special attention to safety when removing or installing heavy items such as engines, transmissions.

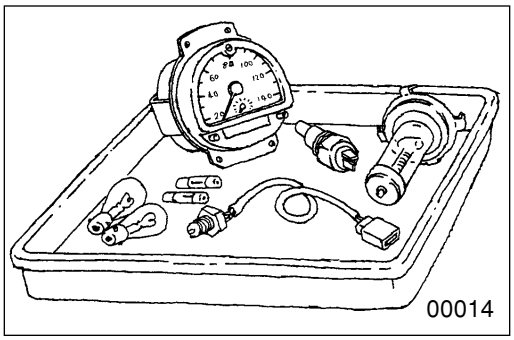
When lifting up heavy items using cables, pay special attention to the following points:

- Check the mass of the item to be lifted and use a cable capable of lifting that mass.

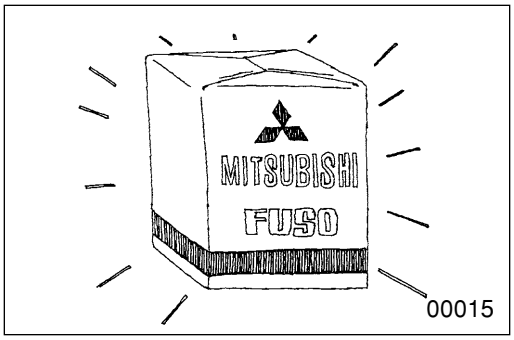


- If you do not have the specified lifting hanger, secure the item using cable taking the point-of-balance of the item into consideration.
- You must work in a position where you will not be injured even if the cable comes undone and the lifted item falls.

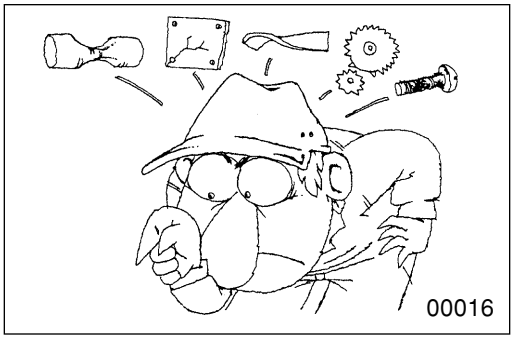
Be particularly careful not to work in shoes that have oily soles and are slippery. When working as a team of two or more, arrange signals in advance and keep confirming safety. Be careful not to accidentally bump switches or levers.



Check for oil leakage before cleaning the area having the fault otherwise you might miss detecting the leakage.
Prepare replacement part(s) beforehand.

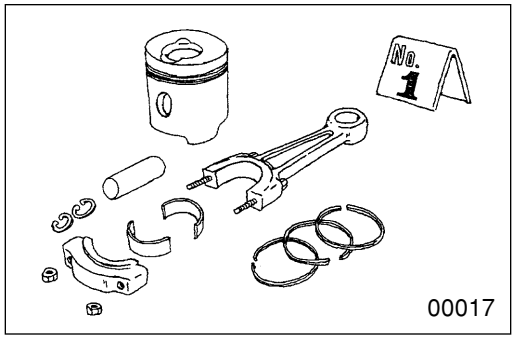


Replace oil seals, packing, O-rings and other rubber parts; gaskets and split pins with new parts whenever any of them has been removed. Use only genuine MITSUBISHI replacement parts.



On disassembly, visually inspect all parts for wear and tear, cracks, damage, deformation, degradation, rust, corrosion, smoothness in rotation, fatigue, clogging and any other possible defect.

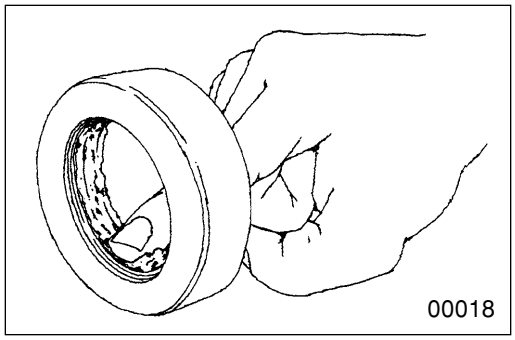
PRECAUTIONS FOR MAINTENANCE OPERATION



Put alignment marks on part combinations before disassembly and arrange the disassembled parts neatly. This will help avoid mismating of the parts later.
Put the alignment marks, punch marks, etc. where performance and appearance will not be affected.
Cover the area left open after removal of parts to keep it free from dust.

CAUTION ⚠

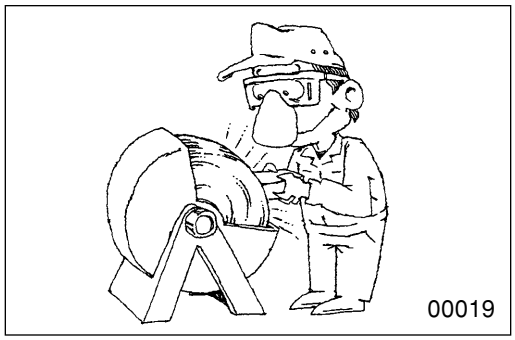
- **Take care to avoid mixing up numerous parts, similar parts, left and right, etc.**
- **Keep new parts for replacement and original (removed) parts separate.**



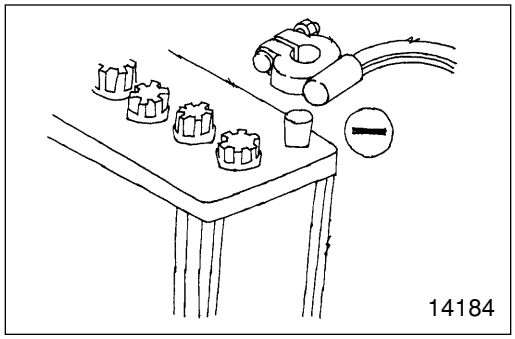
Apply the specified oil or grease to U-packings, oil seals, dust seals and bearings during assembly.
Use only the specified oil, grease, etc. for lubricant, remove the excess immediately after application with a piece of waste, etc.

CAUTION ⚠

When the specified lubricant, fluid and sealant is not available, you may use an equivalent.



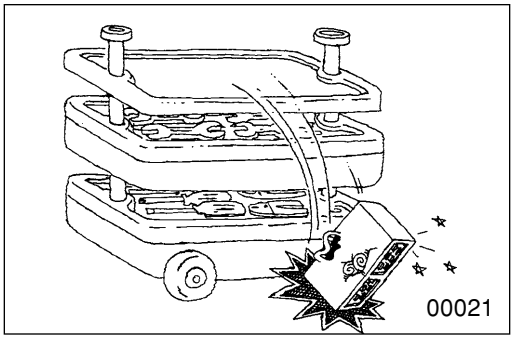
Wear goggles when using a grinder or welder. Pay full attention to safety by wearing gloves when necessary. Watch out for sharp edges, etc. that might injure your hands or fingers.



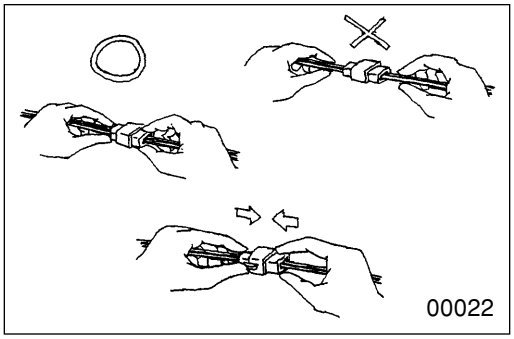
Before carrying out maintenance work on the electric system, disconnect the negative terminals of the batteries to prevent them from short-circuiting and burning-out.

CAUTION ⚠

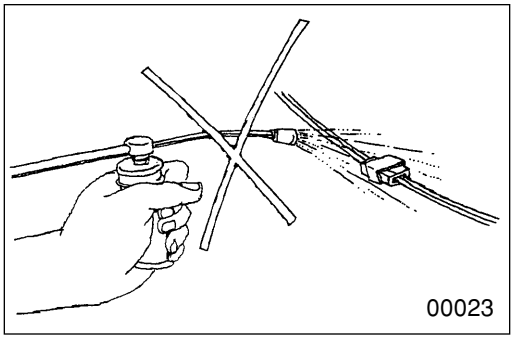
Be sure to turn starter and lighting switches, etc. off before disconnecting or connecting battery terminals, because the semiconductors can be damaged.



Take care when handling sensors, relays, etc. which are vulnerable to shock and heat. Do not attempt to remove the cover from, or apply paint to, the electronic control unit.



Pull the connector, and not the harness lead, to separate connectors. To separate a lock-type connector, first push toward arrow mark. To reconnect a lock-type connector, press the separated parts until they click together.

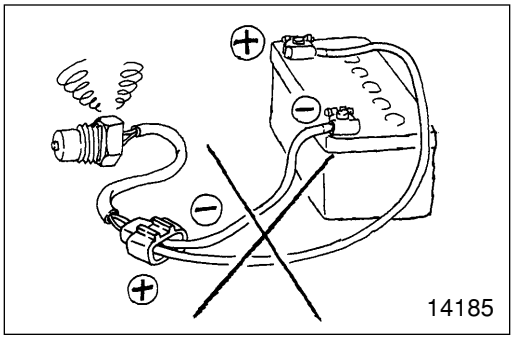


When washing the vehicle, cover the electric system parts and instruments with waterproof material beforehand (Cover with vinyl sheet or the like). Keep water away from harness wire connectors and sensors. If any of them should get wet, wipe them off immediately.

When using an electric welder, such electronic parts that are directly connected to the batteries might be damaged due to the flow of current from the welder that flows through the negative circuit. Parts that have switches might be subject to the same danger if the switches are left on.

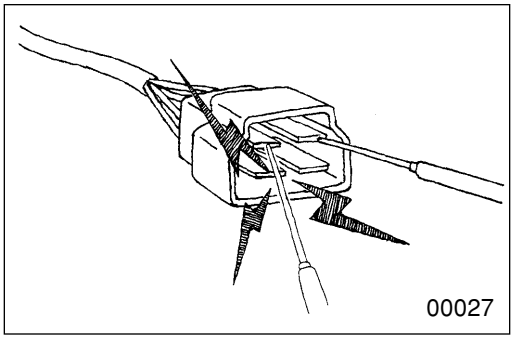
Therefore, do not fail to observe the following.

- Connect the negative terminal of the welder as near as possible to the area that is to be welded.
- Disconnect the negative terminals of batteries.



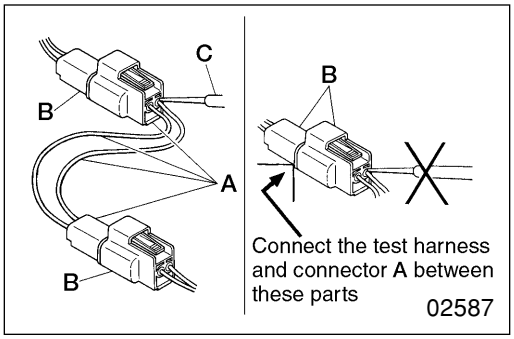
To apply voltage for testing, check that the positive and negative cables are connected properly, then increase voltage gradually from 0 volt. Do not apply voltage higher than the specified value.

In particular, pay close attention to the electronic control unit and sensors, since they are not always fed the battery voltage.

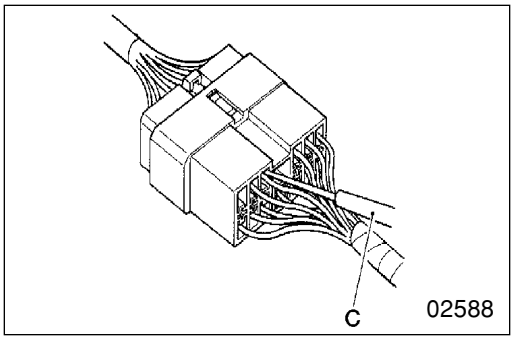


When using testers or the like for continuity tests, be careful not to allow test probes to touch the wrong terminals.

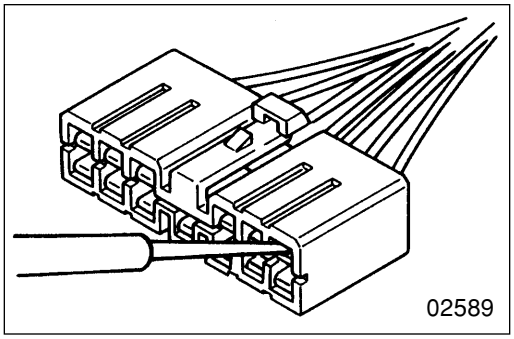
Measurement Procedures Using Connectors



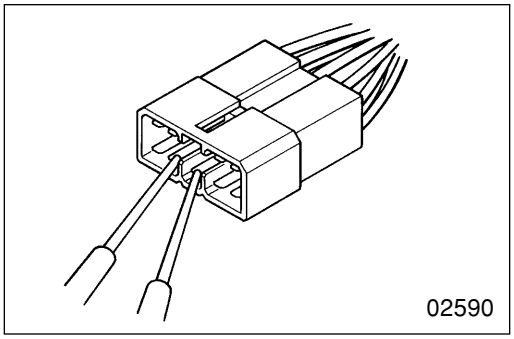
Test with connectors engaged (continuity through circuit obtained)
<Waterproof connector>
Prepare a test harness and connectors **A**, then connect if between the two parts of harness **B** that is to be tested. Check the circuit by touching test probe **C** to the test connector.
Never insert the test probe from the harness side of the waterproof connection, or waterproof performance might be diminished causing corrosion of the connector.



<Non-waterproof connector>
Insert test probe **C** from the harness side of the connector. Where control units, etc. have connectors that are too small to accept the test probe, do not force the test probe into them.



Test with connectors disengaged
Using female pins
Insert a test probe into a terminal. However, do not force the probe into the terminal, or it will cause a poor contact.

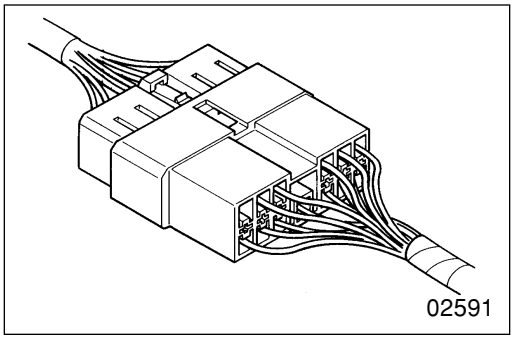


Using male pins
Touch the pins directly using test probes.

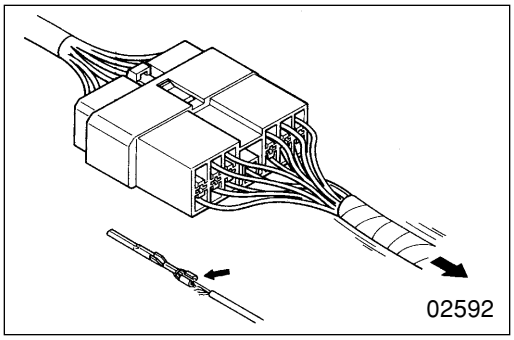
CAUTION ⚠

Be sure that you do not short circuit the connector pins when you use the test probe because this could damage the internal circuit of the electronic control unit.

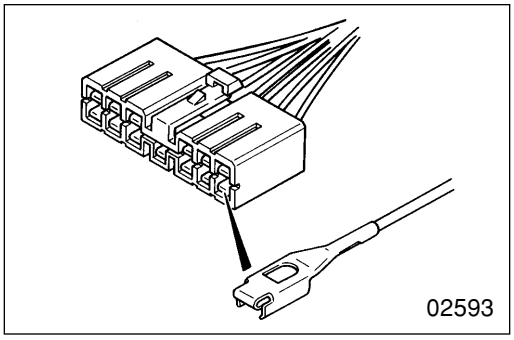
Connector Inspection Procedures



Visual inspection
Check for loose connection and poor engagement.

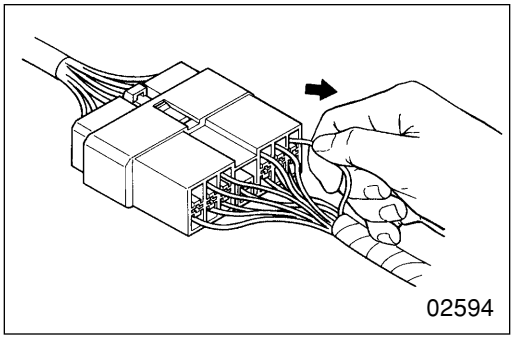


Check if harnesses are broken by pulling gently around the terminals.



Check for a decrease in contact pressure between the male and female terminals.

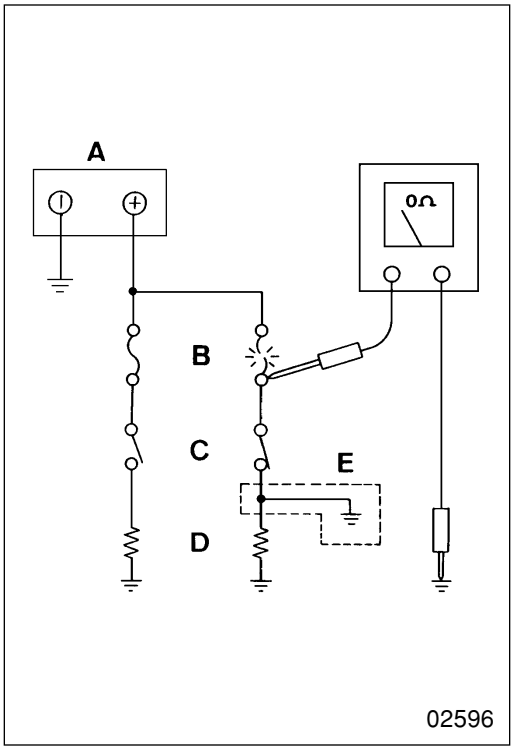
Check for poor contact caused by connector pins having fallen out, rusted terminals or foreign particles.



Connector pin fall out inspection

Damaged connector pin stoppers can cause poor engagement of the terminals (male and female pins) even if the connector body is secured, and might cause some pins to fall out. Check if the pins have fallen out from the connector by pulling each harness gently.

Inspection Procedures for Blown Fuses



Remove fuse B and measure resistance between the loaded side of the fuse and ground.

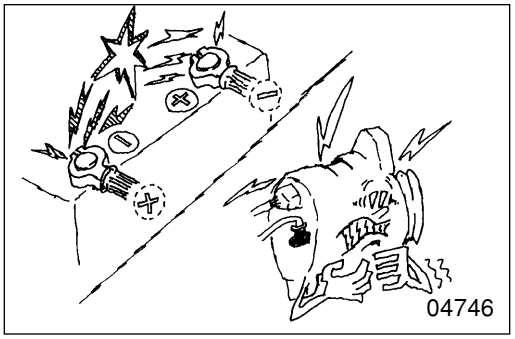
Turn on all circuit switches (connected to the fuse). If the resistance value reading is approximately 0, a short has occurred between the switch and the loaded point. A value of other than zero may indicate that the fuse was blown by a temporary short but the short is no longer present.

The major causes of a short circuit are as follows:

- Harness stuck onto the vehicle body.
- Harness sheath damaged by friction or heat.
- Water in connectors or circuits.
- Mistakes (accidental short circuits)

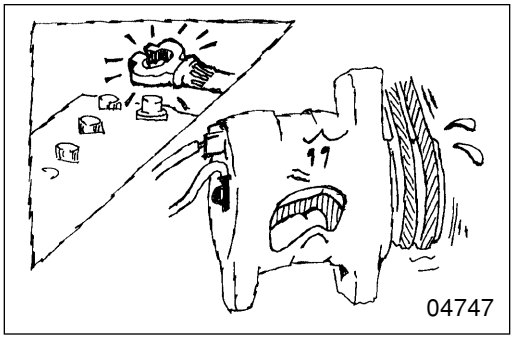
A: Battery
B: Fuse
C: Loaded switch
D: Load
E: Short circuit

Precautions for Handling Alternator

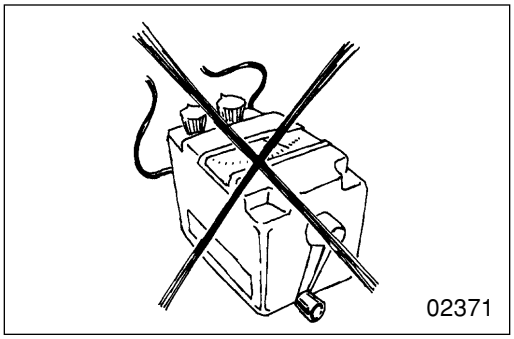


When servicing the alternator, pay attention to the following:

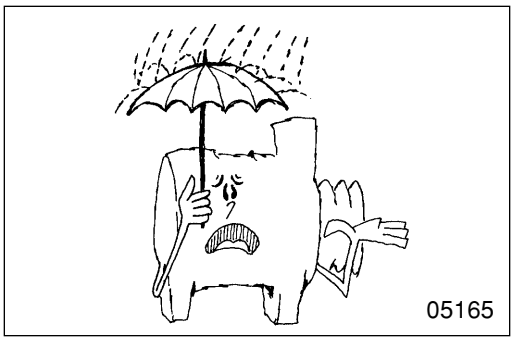
- Do not connect the alternator with battery polarities reversed.
  If the alternator is connected with reversed polarities, a large current flow from the battery to the alternator occurs, and the diode or regulator might be damaged.



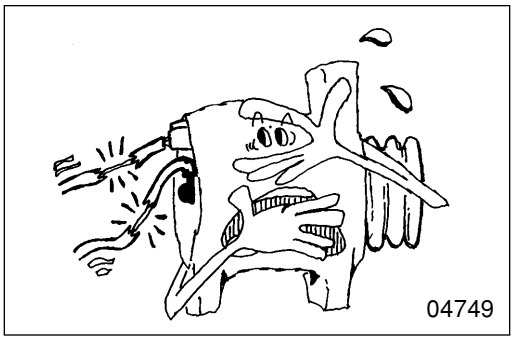
- While the engine is running, do not remove the battery terminals. If the battery terminals are removed at that time, a surge voltage is generated and the diode or regulator might be weakened.



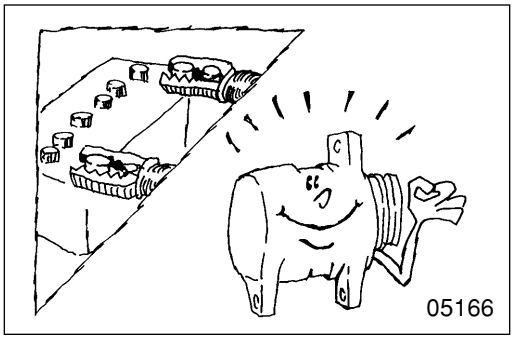
- Do not use a high-voltage tester such as a megger for inspection. If a high-voltage tester is used, the diode or regulator might be destroyed.



- Do not splash water over the alternator.
  If water is directly splashed over the alternator, individual components will be short-circuited and might be destroyed.



- Do not short-circuit terminal B and terminal L while running the alternator.
  If the terminals are short-circuited while the alternator is running, the diode trio might be destroyed.



- Disconnect the battery terminals before quick-charging the battery. Quick-charging without disconnecting the battery terminals might damage the diode or regulator.

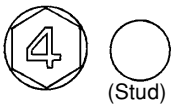
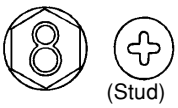
BUY NOW

TABLE OF STANDARD TIGHTENING TORQUES

- Use specified bolts and nuts and tighten them at specified torques according to the following table, unless otherwise specified.
- Threads and contact seats shall be dry.
- Where there is a difference in strength classification between the nut and bolt (or stud bolt), the torque specified for the bolt shall apply.

Hex-head Bolt and Stud Bolt

Unit: N·m (kgf·m) [lbf·ft]

Strength classification	4T		7T		8T	
Repre-sentation / Diameter symbol	 (Stud)		(Stud)		 (Stud)	02154
M5	2 to 3 (0.2 to 0.3) [1.48 to 2.21]	–	4 to 6 (0.4 to 0.6) [2.95 to 4.43]	–	5 to 7 (0.5 to 0.7) [3.69 to 5.16]	–
M6	4 to 6 (0.4 to 0.6) [2.95 to 4.43]	–	7 to 11 (0.7 to 1.1) [5.16 to 8.11]	–	8 to 12 (0.8 to 1.2) [5.90 to 8.85]	–
M8	9 to 14 (0.9 to 1.4) [6.64 to 10.3]	–	17 to 26 (1.7 to 2.6) [12.5 to 19.2]	–	20 to 29 (2.0 to 3.0) [14.8 to 21.4]	–
M10	19 to 28 (1.9 to 2.8) [14.0 to 20.6]	18 to 26 (1.8 to 2.7) [13.3 to 19.2]	36 to 52 (3.5 to 5.5) [26.6 to 38.4]	33 to 49 (3.5 to 5.0) [24.3 to 36.1]	45 to 60 (4.5 to 6.0) [33.2 to 44.3]	41 to 59 (4.3 to 6.9) [30.2 to 43.5]
M12	35 to 50 (3.4 to 5.0) [25.8 to 36.9]	31 to 46 (3.1 to 4.7) [22.9 to 33.9]	70 to 95 (7.0 to 9.5) [51.6 to 70.1]	65 to 85 (6.5 to 8.5) [47.9 to 62.7]	85 to 110 (8.5 to 11) [62.7 to 81.1]	75 to 100 (7.5 to 10) [55.3 to 73.8]
M14	60 to 85 (6.0 to 8.5) [44.3 to 62.7]	55 to 75 (5.5 to 7.5) [40.6 to 55.3]	120 to 160 (12 to 16) [88.5 to 118]	110 to 140 (11 to 14) [81.1 to 103]	130 to 180 (13 to 18) [95.9 to 133]	120 to 160 (12 to 17) [88.5 to 118]
M16	90 to 130 (9.5 to 13) [66.4 to 95.9]	90 to 120 (9.0 to 12) [66.4 to 88.5]	180 to 240 (18 to 24) [133 to 177]	160 to 220 (16 to 22) [118 to 162]	200 to 270 (20 to 27) [148 to 199]	190 to 260 (19 to 26) [140 to 192]
M18	140 to 190 (14 to 19) [103 to 140]	120 to 160 (12 to 16) [88.5 to 118]	260 to 340 (25 to 35) [192 to 251]	220 to 290 (22 to 30) [162 to 214]	290 to 390 (30 to 40) [214 to 288]	260 to 340 (26 to 35) [192 to 251]
M20	190 to 260 (19 to 26) [140 to 192]	170 to 230 (17 to 23) [125 to 170]	350 to 470 (36 to 48) [251 to 347]	320 to 420 (32 to 43) [236 to 310]	410 to 550 (41 to 56) [302 to 406]	370 to 490 (37 to 50) [273 to 361]
M22	260 to 340 (26 to 35) [192 to 251]	230 to 300 (23 to 31) [170 to 221]	470 to 640 (48 to 65) [347 to 472]	430 to 570 (43 to 58) [317 to 420]	550 to 740 (56 to 75) [406 to 546]	490 to 670 (50 to 68) [361 to 494]
M24	340 to 450 (34 to 46) [251 to 332]	290 to 390 (29 to 40) [214 to 288]	630 to 840 (63 to 86) [465 to 620]	540 to 730 (55 to 74) [398 to 538]	730 to 980 (74 to 100) [538 to 723]	630 to 840 (64 to 86) [465 to 620]

Hex-head Flange Bolt

Unit: N·m (kgf·m) [lbf·ft]

Strength classification	4T		7T		8T	
Repre-sentation / Diameter symbol						02154
M6	4 to 6 (0.4 to 0.6) [2.95 to 4.43]	–	8 to 12 (0.8 to 1.2) [5.90 to 8.85]	–	9 to 14 (0.9 to 1.4) [6.64 to 10.3]	–
M8	10 to 15 (1.0 to 1.5) [7.38 to 11.1]	–	19 to 28 (1.9 to 2.8) [14.0 to 20.6]	–	22 to 32 (2.2 to 3.3) [16.2 to 23.6]	–
M10	21 to 30 (2.1 to 3.1) [15.5 to 22.1]	20 to 28 (1.9 to 2.9) [14.8 to 20.6]	39 to 58 (3.9 to 6.0) [28.8 to 42.8]	37 to 53 (3.6 to 5.4) [27.3 to 39.1]	50 to 65 (5.0 to 6.5) [66.8 to 47.9]	45 to 65 (4.5 to 6.5) [33.2 to 47.9]
M12	38 to 54 (3.8 to 5.5) [28.0 to 39.8]	35 to 51 (3.4 to 5.2) [25.8 to 37.6]	80 to 110 (8.0 to 11) [59.0 to 81.1]	70 to 95 (7.0 to 9.5) [51.6 to 70.1]	90 to 120 (9.0 to 12) [66.4 to 88.5]	85 to 110 (8.5 to 11) [62.7 to 81.1]

TABLE OF STANDARD TIGHTENING TORQUES

Hex-head Nut

Unit: N·m (kgf·m) [lbf·ft]

Strength classification	4T		6T	
Representation / Diameter symbol			02155	
	Standard screw	Coarse screw	Standard screw	Coarse screw
M5	2 to 3 (0.2 to 0.3) [1.48 to 2.21]	–	4 to 6 (0.4 to 0.6) [2.95 to 4.43]	–
M6	4 to 6 (0.4 to 0.6) [2.95 to 4.43]	–	7 to 11 (0.7 to 1.1) [5.16 to 8.11]	–
M8	9 to 14 (0.9 to 1.4) [6.64 to 10.3]	–	17 to 26 (1.7 to 2.6) [12.5 to 19.2]	–
M10	19 to 28 (1.9 to 2.8) [14.0 to 20.6]	18 to 26 (1.8 to 2.7) [13.3 to 19.2]	36 to 52 (3.5 to 5.5) [26.6 to 38.4]	33 to 49 (3.5 to 5.0) [24.3 to 36.1]
M12	35 to 50 (3.4 to 5.0) [25.8 to 36.9]	31 to 46 (3.1 to 4.7) [22.9 to 33.9]	70 to 95 (7.0 to 9.5) [51.6 to 70.1]	65 to 85 (6.5 to 8.5) [47.9 to 62.7]
M14	60 to 85 (6.0 to 8.5) [44.3 to 62.7]	55 to 75 (5.5 to 7.5) [40.6 to 55.3]	120 to 160 (12 to 16) [88.5 to 118]	110 to 140 (11 to 14) [81.1 to 103]
M16	90 to 130 (9.5 to 13) [66.4 to 95.9]	90 to 120 (9.0 to 12) [66.4 to 88.5]	180 to 240 (18 to 24) [133 to 177]	160 to 220 (16 to 22) [118 to 162]
M18	140 to 190 (14 to 19) [103 to 140]	120 to 160 (12 to 16) [88.5 to 118]	260 to 340 (25 to 35) [192 to 251]	220 to 290 (22 to 30) [162 to 214]
M20	190 to 260 (19 to 26) [140 to 192]	170 to 230 (17 to 23) [125 to 170]	350 to 470 (36 to 48) [251 to 347]	320 to 420 (32 to 43) [236 to 310]
M22	260 to 340 (26 to 35) [192 to 251]	230 to 300 (23 to 31) [170 to 221]	470 to 640 (48 to 65) [347 to 472]	430 to 570 (43 to 58) [317 to 420]
M24	340 to 450 (34 to 46) [251 to 332]	290 to 390 (29 to 40) [214 to 288]	630 to 840 (63 to 86) [465 to 620]	540 to 730 (55 to 74) [398 to 538]

Hex-head Flange Nut

Unit: N·m (kgf·m) [lbf·ft]

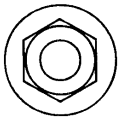
Strength classification	4T	
Repre-sentation / Diameter symbol	 02155	
	Standard screw	Coarse screw
M6	4 to 6 (0.4 to 0.6) [3.69 to 5.16]	–
M8	10 to 15 (1.0 to 1.5) [2.95 to 4.43]	–
M10	21 to 30 (2.1 to 3.1) [7.38 to 11.1]	20 to 28 (1.9 to 2.9) [28.0 to 39.8]
M12	38 to 54 (3.8 to 5.5) [15.5 to 22.1]	35 to 51 (3.4 to 5.2) [14.8 to 20.6]

TABLE OF STANDARD TIGHTENING TORQUES

Tightening torque for flare nut for general purpose

Unit: N·m (kgf·m) [lbf·ft]

Pipe diameter	ϕ4.76 mm (ϕ0.187 in.)	ϕ6.35 mm (ϕ0.250 in.)	ϕ8 mm (ϕ0.315 in.)	ϕ10 mm (ϕ0.394 in.)	ϕ12 mm (ϕ0.472 in.)	ϕ15 mm (ϕ0.591 in.)
Tightening torque	17 (1.7) [12.5]	25 (2.6) [18.4]	39 (4.0) [28.8]	59 (6.0) [43.5]	88 (9.0) [64.9]	98 (10.0) [72.3]

Tightening torque for air piping nylon tube for general purpose {DIN type}

Unit: N·m (kgf·m) [lbf·ft]

Standard diameter	6 × 1 mm (0.236 × 0.0394 in.)	10 × 1.25 mm (0.394 × 0.0492 in.)	12 × 1.5 mm (0.472 × 0.0591 in.)	15 × 1.5 mm (0.591 × 0.0591 in.)
Tightening torque	20^{+6}_{-0} $\left(2.0^{+0.6}_{-0}\right)$ $\left[14.8^{+0.4}_{-0}\right]$	29^{+10}_{-0} $\left(3.0^{+1.0}_{-0}\right)$ $\left[21.4^{+0.7}_{-0}\right]$	49^{+10}_{-0} $\left(5.0^{+1.0}_{-0}\right)$ $\left[36.1^{+0.7}_{-0}\right]$	54^{+5}_{-0} $\left(5.5^{+1.0}_{-0}\right)$ $\left[39.8^{+0.7}_{-0}\right]$

Tightening torque for air piping nylon tube for general purpose {SAE type}

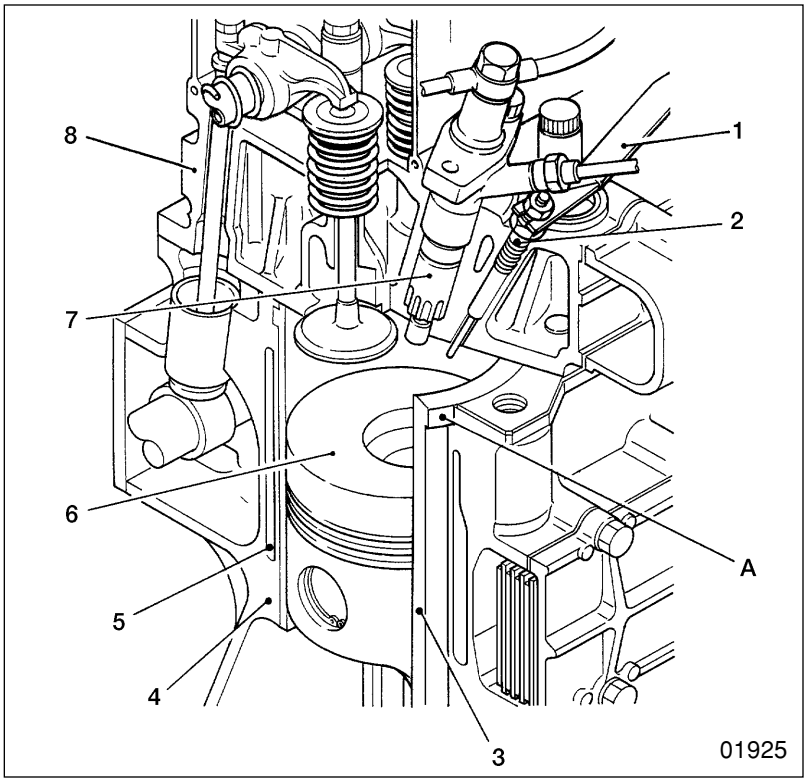
Unit: N·m (kgf·m) [lbf·ft]

Standard diameter	1/4 in.	3/8 in.	1/2 in.	5/8 in.
Tightening torque	13^{+4}_{-0} $\left(1.3^{+0.4}_{-0}\right)$ $\left[9.59^{+0.30}_{-0}\right]$	29^{+5}_{-0} $\left(3.0^{+0.5}_{-0}\right)$ $\left[21.4^{+0.4}_{-0}\right]$	49^{+5}_{-0} $\left(5.0^{+0.5}_{-0}\right)$ $\left[36.1^{+0.4}_{-0}\right]$	64^{+5}_{-0} $\left(6.5^{+0.5}_{-0}\right)$ $\left[47.2^{+0.4}_{-0}\right]$

SPECIFICATIONS

Item		Specifications	
Engine model		6D16	6D16-TLE
Type		6-cylinder, in-line, water-cooled, 4-cycle diesel	
Combustion chamber type		Direct injection	
Valve mechanism		Overhead valve	
Cylinder bore × stroke	mm (in.)	ϕ118 × 115 (ϕ4.65 × 4.53)	
Total displacement	cc (cu. in.)	7545 (460.4)	
Compression ratio		17.5	

1. Cylinder Head and Crankcase

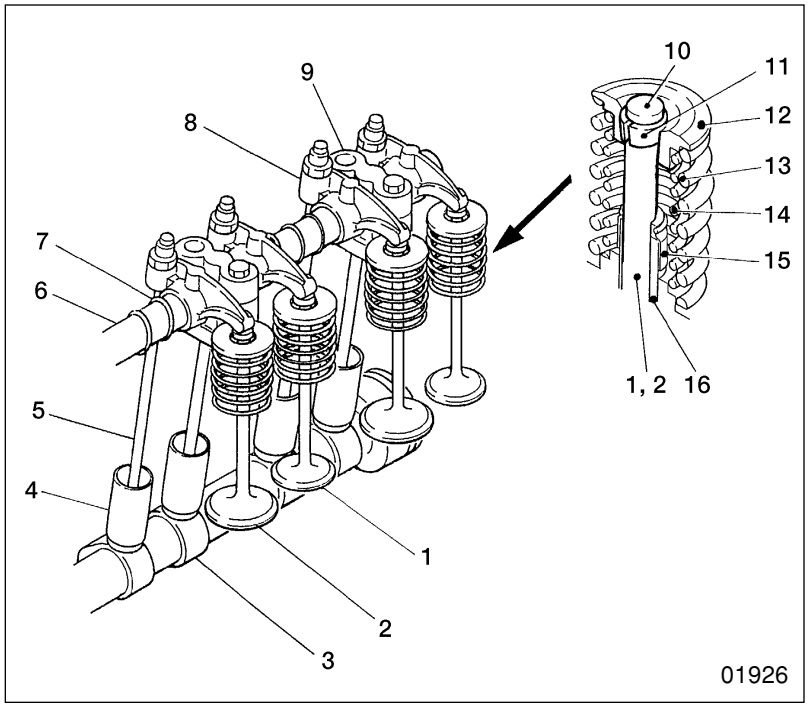


1 Connecting plate
2 Glow plug
3 Cylinder liner
4 Crankcase
5 Water jacket
6 Piston
7 Injection nozzle
8 Cylinder head

A: Cylinder liner size mark
Outer diameter mark: 1, 2, 3
Inner diameter mark: A, B

- The cylinder liners **3** are a dry type liners that are easier to remove than wet liners. Liners are press-fitted into the crankcase **4**.
- The cylinder liners **3**, crankcase **4**, and pistons **6** have size marks. They should be combined as specified according to the size marks. 🕮 P.11-36

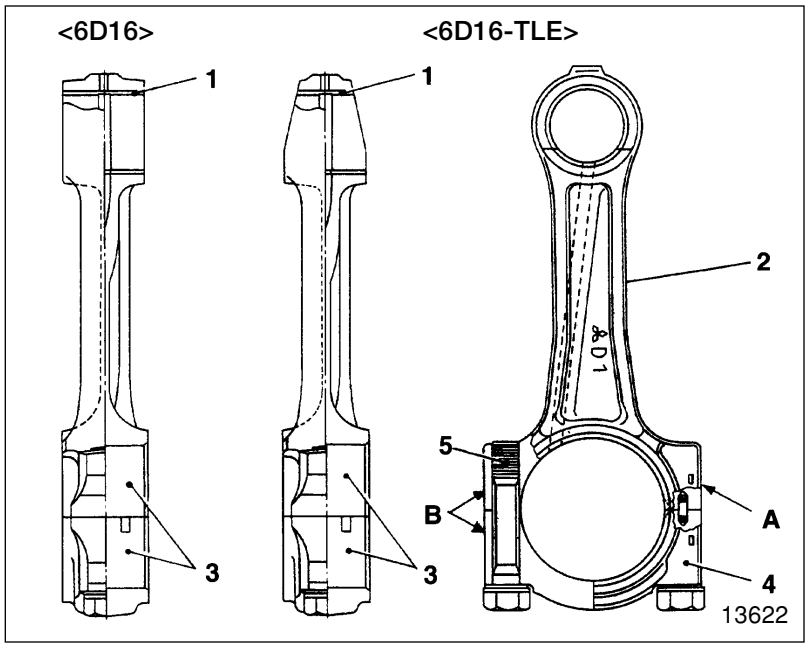
2. Valve Mechanism



1 Exhaust valve
2 Inlet valve
3 Camshaft
4 Tappet
5 Push rod
6 Rocker shaft
7 Rocker shaft spring
8 Rocker
9 Rocker shaft bracket
10 Valve cap
11 Valve cotter
12 Upper retainer
13 Outer valve spring
14 Inner valve spring
15 Valve stem seal
16 Valve guide

- The valve stem seals **15** are fitted onto the valves **1**, **2** to control the amount of lubricant flowing onto the sliding surfaces of the valves **1**, **2** and valve guides **16**.
- The valve springs **13**, **14** are unevenly pitched to prevent abnormal vibration at high speeds. To prevent the inner and outer springs from meshing with each other, the springs are wound in opposite directions.
- To facilitate removal and reinstallation of the camshaft from the rear end of the crankcase, the diameter of each bushing is smaller toward the front of the engine.

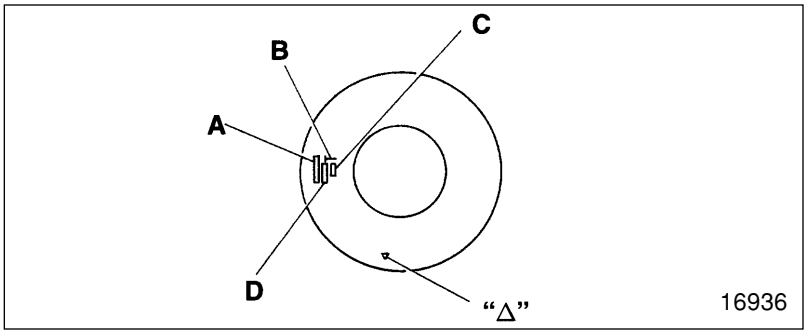
3. Connecting Rods



1 Connecting rod bushing
2 Connecting rod
3 Connecting rod bearing
4 Connecting rod cap
5 Connecting rod bolt

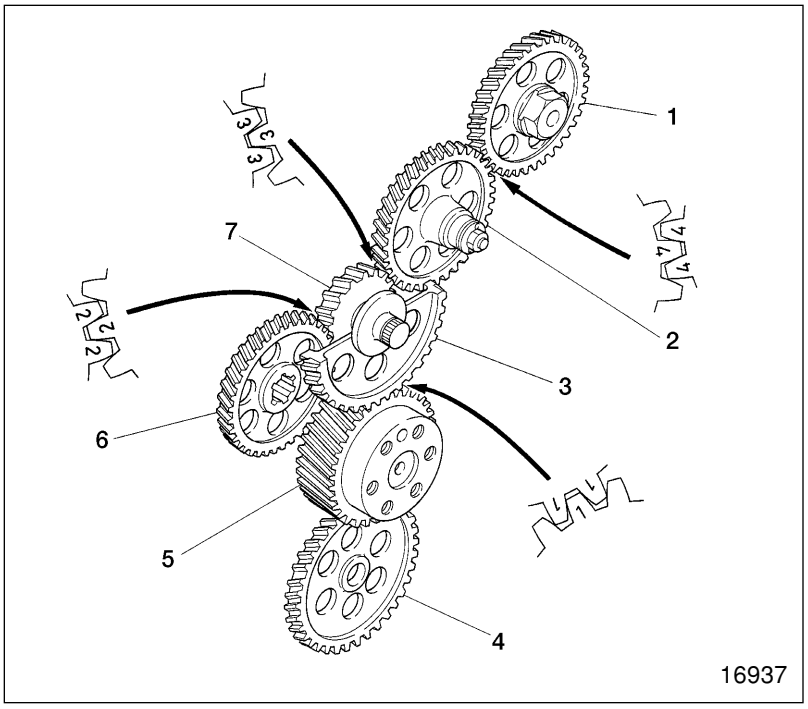
A: Alignment mark
B: Weight mark stamp
(A, B, C, D, E, F, G, H, I, V, W, X, Y, Z: <6D16>)
(A, B, C, D, E, F: <6D16-TLE>)

4. Pistons



A: Part number
B: "T" mark <6D16-TLE>
C: Size mark (A, B: <6D16, 6D16-TLE>)
D: Weight mark
Δ: Front mark

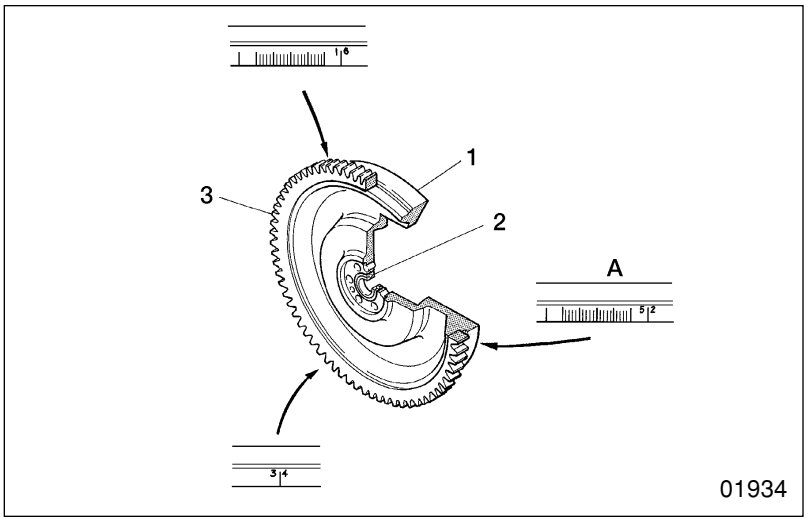
5. Timing Gears



1 Camshaft gear
2 No. 2 idler gear
3 No. 1 idler gear
4 Oil pump gear
5 Crankshaft gear
6 Air compressor drive gear or injection pump drive gear
7 No. 1 idler gear

Each gear is stamped with a timing gear alignment mark ("**1**", "**2**", "**3**", or "**4**") to facilitate reassembly.

6. Flywheel



1 Flywheel
2 Pilot bearing
3 Ring gear

A: Angle scale, cylinder number

Symptoms / Possible causes	Low power output	Abnormal engine noise	Remarks
Incorrect oil viscosity	○		🕮 Gr 11
Incorrect/defective fuel	○		🕮 Gr 13
Incorrect valve clearance	○	○	
Defective cylinder head gasket	○	○	
Worn valve/valve seat, and carbon deposits	○	○	
Weakened valve spring	○	○	
Worn/damaged piston ring(s)	○	○	
Worn/damaged piston ring groove(s)	○	○	
Incorrect injection timing	○	○	🕮 Gr 13
Defective injection pump	○	○	🕮 Gr 13
Defective cooling system	○		🕮 Gr 14
Defective injection nozzle(s)	○	○	🕮 Gr 13
Air trapped in fuel system	○		🕮 Gr 13
Clogged air cleaner	○		🕮 Gr 15
Clogged muffler	○		🕮 Gr 15
Defective turbocharger	○	○	🕮 Gr 15
Incorrectly fitted pipe(s)/hose(s)		○	🕮 Gr 13
Injection pump, alternator, or other auxiliary device(s) defective/incorrectly fitted		○	🕮 Gr 13, 54
Loose/damaged V-belt		○	🕮 Gr 14
Incorrectly fitted crankshaft pulley		○	
Defective air cleaner or muffler		○	🕮 Gr 15
Defective valve spring(s)		○	
Defective rocker shaft and bracket		○	
Incorrect lubrication of rocker shaft bracket		○	
Incorrect backlash in timing gears		○	
Incorrect lubrication of timing gear peripheries and idler shafts		○	
Worn connecting rod small end bushing and piston pin		○	
Worn/damaged crankshaft pin and connecting rod big end bearing		○	
Worn/damaged crankshaft journal and main bearing		○	
Excessive end play in crankshaft and camshaft		○	
Worn tappet(s) and camshaft		○	

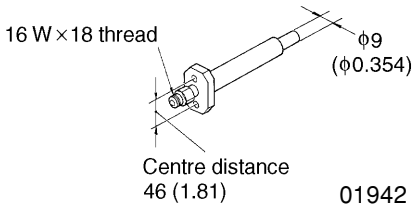
1. Measuring Compression Pressure

Service standards

Location	Maintenance item		Standard value	Limit	Remedy
–	Compression pressure	Each cylinder (at 200 rpm)	2550 kPa (26 kgf/cm²) [370 psi]	1960 kPa (20 kgf/cm²) [284 psi]	Inspect
		Cylinder-to-cylinder pressure difference	–	390 kPa (4 kgf/cm²) [56.6 psi]	Inspect

Special tools

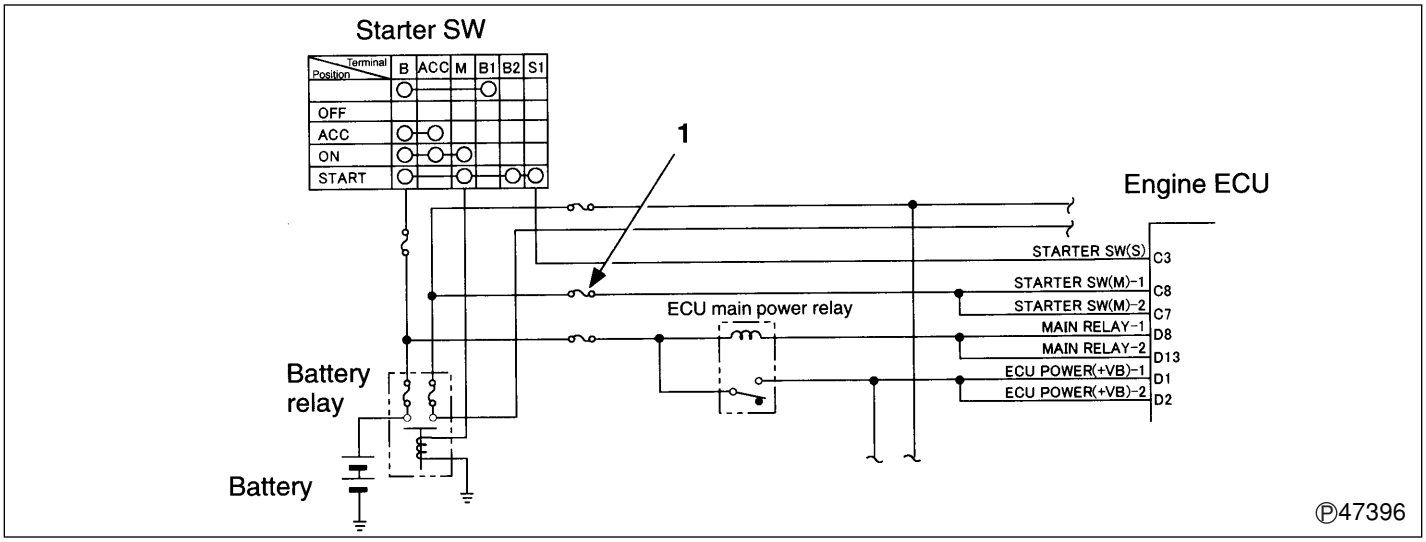
Unit: mm (in.)

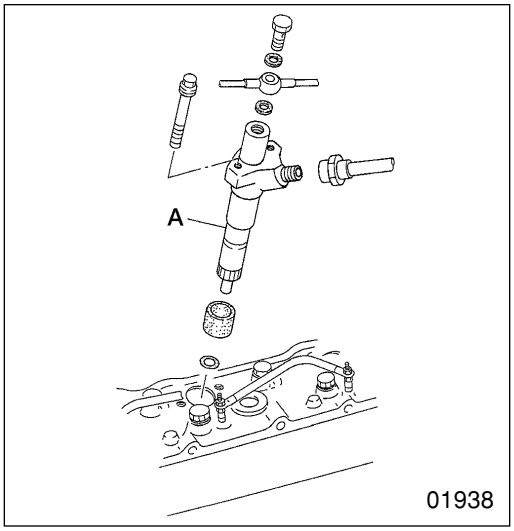
Location	Tool name and shape	Part No.	Application
–	Compression Gauge Adapter 	MH061461	Measuring compression pressure

Reductions in compression pressure should be used as a guide in determining the timing of engine overhauls. Take measurements regularly and keep track of changes; an overview of pressure variations can be useful in fault diagnosis.

During the engine's run-in period and after parts have been replaced, the compression pressure will increase slightly as piston rings, valve seats, and other parts fit snugly in position. The pressure will then normalize as parts wear.

- Before inspections, check that the engine oil, starter, and battery are normal.
- Warm up the engine until the coolant temperature reaches 75 to 85°C (167 to 185°F).
- Turn off all lights and auxiliary devices.
- To prevent injection of fuel while cranking the engine by the starter, perform the following steps.
  - Set the stop lever of the injection pump governor to the stop position. <Mechanical governor>
  - Remove fuse **1** shown in the diagram below. For the terminal arrangement of the engine ECU, refer to Gr 13E. <Electronic governor>

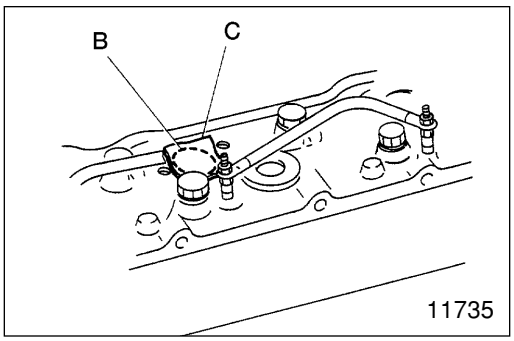




- Remove the injection nozzle **A**.
  Gr 13

CAUTION ⚠

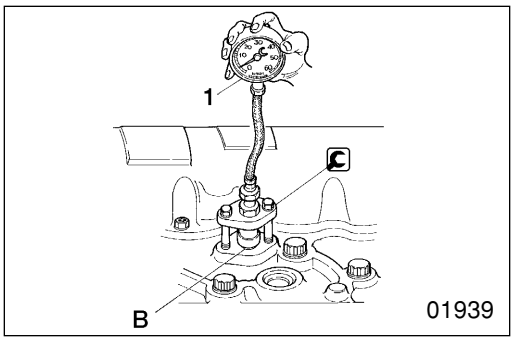
Cover the mounting holes and injection pipes to prevent the entry of dust and dirt.



- Cover the injection nozzle mounting hole **B** with a cloth **C**. Then, turn the engine over with the starter and check that no foreign matter adheres to the cloth.

WARNING ⚠

If any cylinder is cracked, coolant, engine oil, and fuel will enter the cylinder through the crack. When the engine is turned over, these substances will spray out of the nozzle mounting hole B at a high temperature. For safety, move away from the nozzle mounting hole before turning over the engine.



- Fit the 🔧 Compression Gauge Adapter onto an injection nozzle mounting hole **B** together with a nozzle gasket. Then, connect the compression gauge **1**.
- Turn the engine over and measure the compression pressure.
- Measure the compression pressure in every cylinder and determine the pressure differences between cylinders.
- If any compression pressure or cylinder-to-cylinder pressure difference exceeds the specified limit, pour a little engine oil into the cylinder via the injection nozzle mounting hole **B** then take the measurement again.
  - If the compression pressure increases, there may be wear or damage on piston rings and inner surfaces of cylinders.
  - If the compression pressure does not increase, valves may be seized or incorrectly seated, or the cylinder head gasket may be defective.

2. Inspecting and Adjusting Valve Clearances

Service standards

Unit: mm (in.)

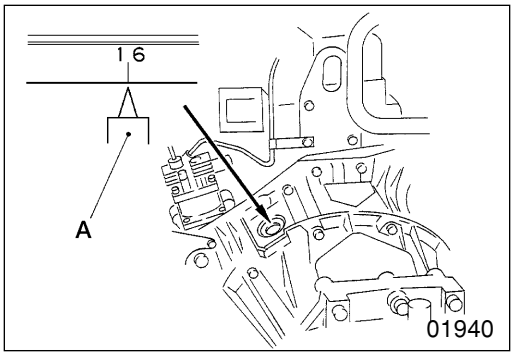
Location	Maintenance item	Standard value	Limit	Remedy
–	Valve clearance (when cold)	0.4 (0.0158)	–	Adjust

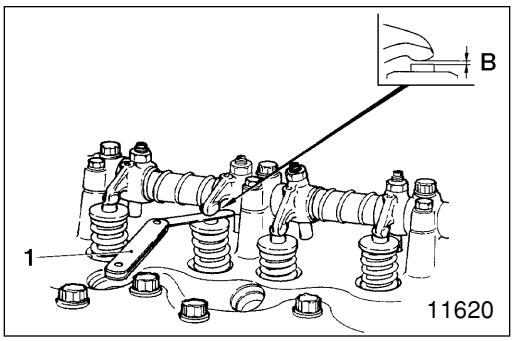
ⓣ Tightening torques

Unit: N·m (kgf·m) [lbf·ft]

Location	Parts to be tightened	Tightening torque	Remarks
2, 3	Rocker arm adjusting screw lock nut	34 (3.5) [25.1]	–

Valve clearances should be checked and adjusted when the engine is cold.





[Inspection]

- Bring piston No. 1 or piston No. 6 to the top-dead-centre (TDC) position of its compression stroke. To do this, crank the engine until the "**1.6**" mark inscribed on the flywheel is aligned with the pointer **A** in the flywheel housing inspection window.

NOTE

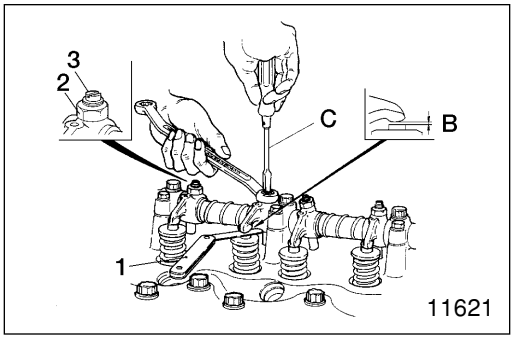
Pistons whose push rods are not pushing up their rockers are at top-dead-centre (TDC) of their compression strokes.

- When piston No. 1 or piston No. 6 is at the TDC position of its compression stroke, measure the clearance **B** of every valve marked "○" in the following table.

Piston No.	1		2		3		4		5		6	
Valve arrangement	In.	Ex.	In.	Ex.	In.	Ex.	In.	Ex.	In.	Ex.	In.	Ex.
No. 1 piston at TDC of compression stroke	○	○	○	×	×	○	○	×	×	○	×	×
No. 6 piston at TDC of compression stroke	×	×	×	○	○	×	×	○	○	×	○	○

NOTE

To measure the clearance, insert a feeler gauge 1. The gauge should be able to move in the gap, albeit not loosely. Accurate measurements cannot be taken if the gauge moves loosely in the gap.

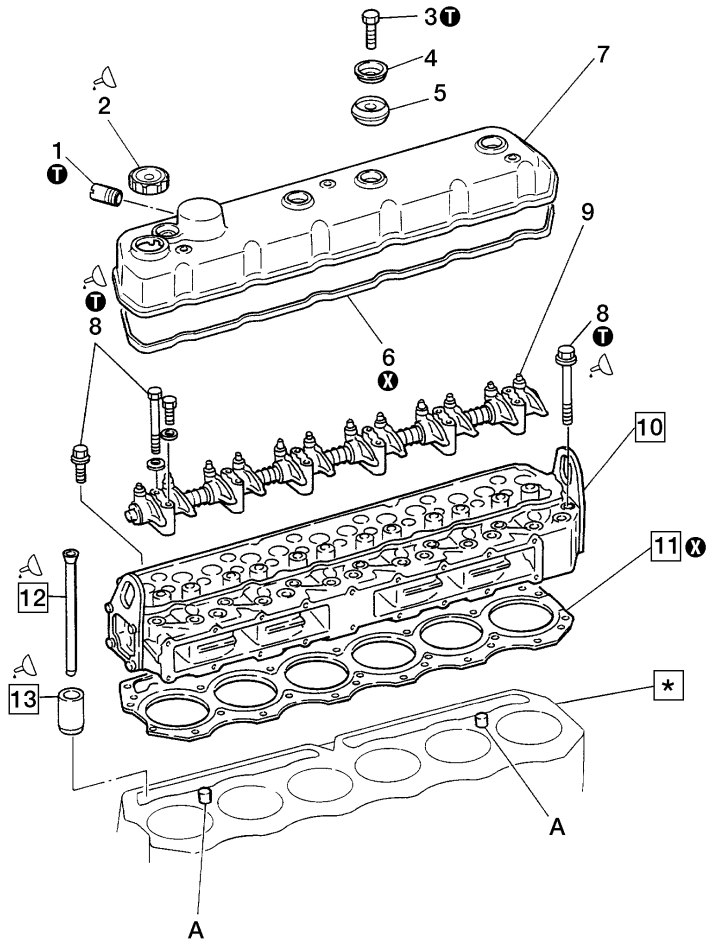


- If any measurement is out of specification, make adjustments as follows:

[Adjustment]

- To adjust the valve clearance **B**, loosen the lock nut **2** and turn the adjusting screw **3** until the feeler gauge **1** moves more stiffly in the gap.
- After adjusting the clearance, tighten the lock nut **2**. At this time, use a screwdriver **C** to stop the adjusting screw **3** from turning. Next, insert the feeler gauge **1** once more to confirm that the clearance **B** is correct.

CYLINDER HEAD AND VALVE MECHANISM



04134

● **Disassembly sequence**

1 Joint
2 Oil filler cap
3 Bolt
4 Plate
5 Rubber
6 Rocker cover gasket
7 Rocker cover
8 Cylinder head bolt
9 Rocker and bracket assembly P.11-16
10 Cylinder head and valve assembly P.11-20
11 Cylinder head gasket
12 Push rod
13 Tappet

*: Crankcase P.11-66
A: Locating pin
X: Non-reusable part

● **Assembly sequence**

Follow the disassembly sequence in reverse.

Service standards

Unit: mm (in.)

Location	Maintenance item		Standard value	Limit	Remedy
12	Push rod runout		–	0.4 (0.0157)	Replace
13, *	Tappet-to-crankcase clearance [Basic diameter: 31 mm (1.220 in.)]	6D16	0.06 to 0.10 (0.00237 to 0.00394)	0.2 (0.00787)	Replace tappet
		6D16-TLE	0.03 to 0.07 (0.00118 to 0.00276)	0.1 (0.00394)	

Tightening torques

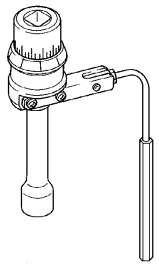
Unit: N·m (kgf·m) [lbf·ft]

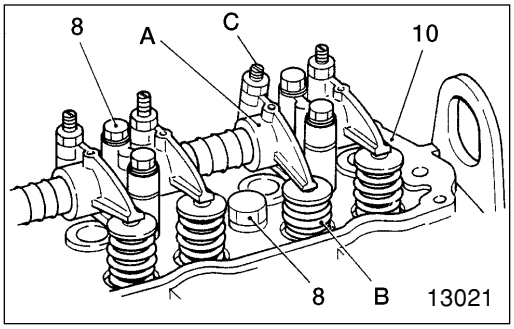
Location	Parts to be tightened		Tightening torque	Remarks
1	Joint		29 (3.0) [21.4]	–
3	Rocker cover bolt		3.9 (0.4) [2.88]	–
8	Cylinder head bolt (installation of rocker and bracket assembly and cylinder head and valve assembly)	M14 bolt	78 (8) [57.5] + 180°	• Wet • Can be reused up to 3 times
		M10 bolt	17 (1.75) [12.5] + 34 (3.5) [25.1]	–

Lubricant

Location	Points of application	Specified lubricant	Quantity
2	Rubber seal of oil filler cap	Engine oil	As required
8	Threads of cylinder head bolts	Engine oil	As required
12	Both ends of push rods	Engine oil	As required
13	Outer surfaces of tappets	Engine oil	As required

Special tools

Location	Tool name and shape	Part No.	Application
10	Socket Wrench  01984	MH063388	Tightening cylinder head bolts (M14 bolt only)

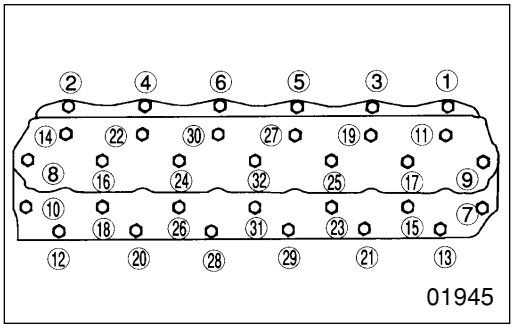


◆ Service procedure

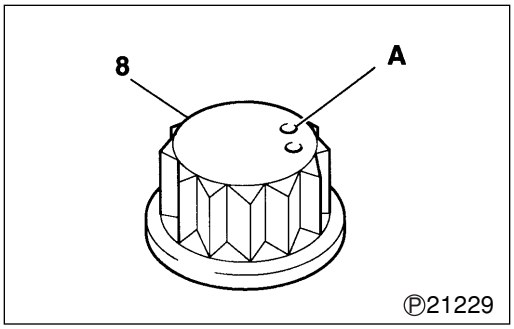
10 Cylinder head and valve assembly

[Removal]

- Before loosening the cylinder head bolts **8**, loosen the adjusting screw **C** on every rocker **A** that is compressing its valve spring **B**.



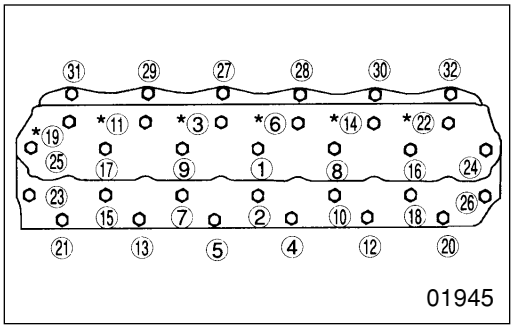
- Loosen and remove the cylinder head bolts **8** in the sequence shown. Each cylinder head bolt should be loosened a little at a time.



[Installation]

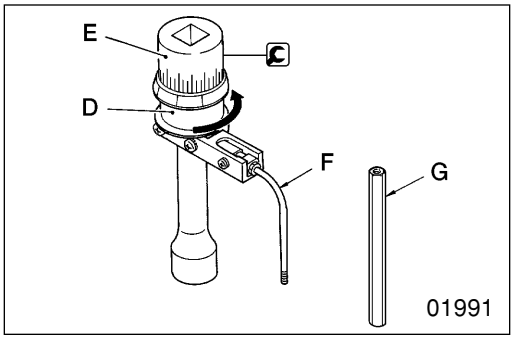
CAUTION ⚠

Before fitting any cylinder head bolt 8, check the punch marks A on its head. Do not use the bolt if there are more than two punch marks. The punch marks indicate the number of times each bolt has been tightened using the plastic area tightening method. Any bolt that already has three punch marks must be replaced.



- Tighten the cylinder head bolts **8** to the specified torque {M14 bolts: 78 N·m (8 kgf·m) [57.5 lbf·ft]; M10 bolts: 17 N·m (1.75 kgf·m) [12.5 lbf·ft]} in the sequence shown. Then, turn the bolts further in accordance with the following procedure.

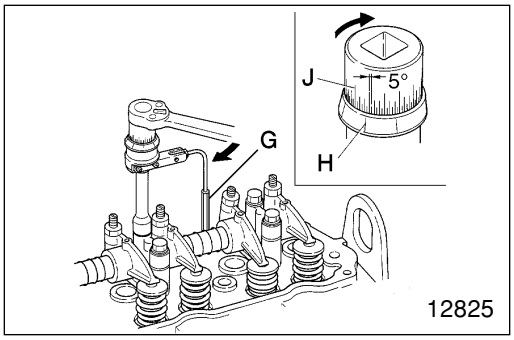
*: Tighten together with rocker and bracket assembly
① to ㉖ : M14 bolt (wet)
㉗ to ㉜ : M10 bolt



<M14 Bolts>

- Before fitting the Socket Wrench over a cylinder head bolt, turn the holder **D** counter-clockwise to tension the built-in spring.

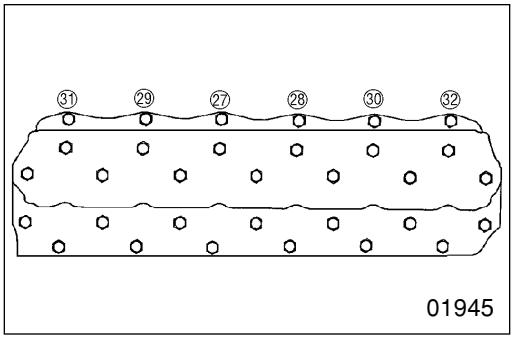
E: Socket
F: Rod
G: Rod (extension)



- Set the socket such that the built-in spring force forces the rod **G** against the rocker shaft bracket, an injection pipe, or another nearby part.
- On the holder **D**, select the inscribed line **H** that is easiest to see.
- Using the selected line as a reference, turn the socket **E** 180° clockwise. (One gradation on the scale **J** represents 5°.)

CAUTION ⚠

Since the M14 cylinder head bolts 8 utilize the plastic region tightening method, they must not be tightened further after this procedure.



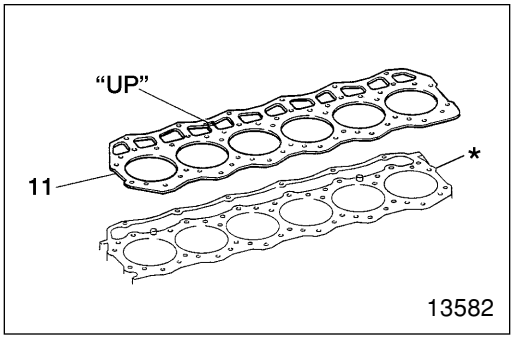
<M10 Bolts>
- After fitting the M14 cylinder head bolts **8**, tighten the M10 bolts to the specified torque {34 N·m (3.5 kgf·m) [25.1 lbf·ft]} in the sequence shown.

11 **Cylinder head gasket**

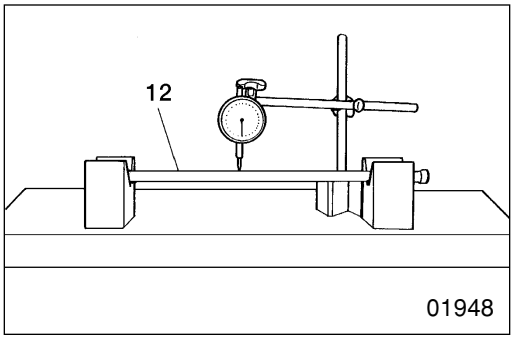
[Removal]

CAUTION ⚠

When removing the cylinder head gasket 11, be careful not to scratch the cylinder head and valve assembly 10 and the crankcase ∗.

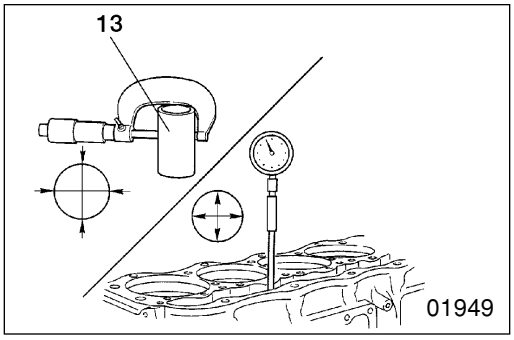


[Fitting]
- Fit the cylinder head gasket **11** onto the crankcase ∗ as shown.



12 **Push rod runout**

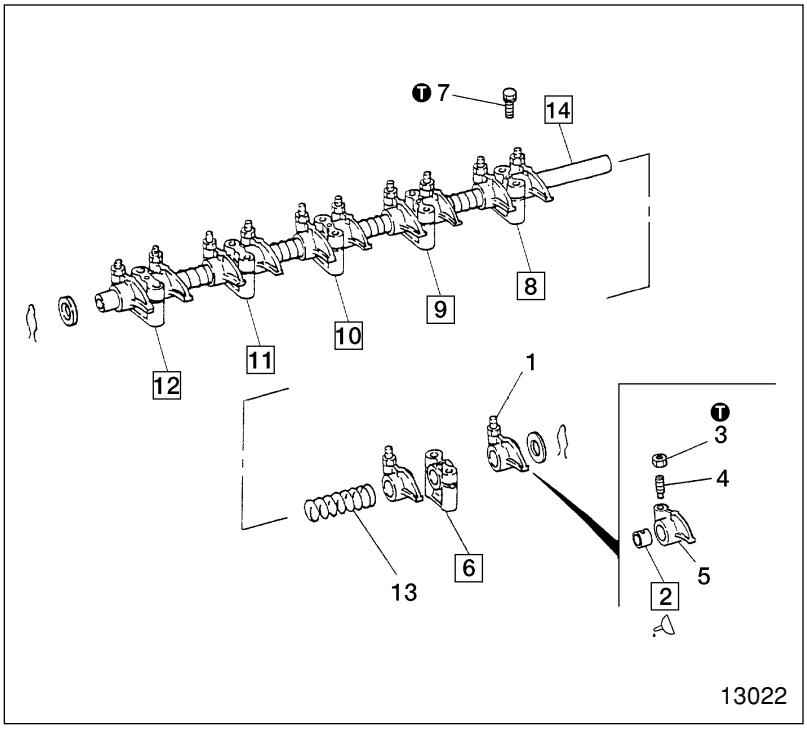
If any measurement exceeds the specified limit, replace the defective part(s).



13 **∗** **Tappet-to-crankcase clearance**

If any measurement exceeds the specified limit, replace the defective part(s).

Rocker and Bracket Assembly



● **Disassembly sequence**

1 Rocker assembly
2 Rocker bushing
3 Lock nut
4 Adjusting screw
5 Rocker
6 No. 6 rocker shaft bracket
7 Set screw
8 No. 5 rocker shaft bracket
9 No. 4 rocker shaft bracket
10 No. 3 rocker shaft bracket
11 No. 2 rocker shaft bracket
12 No. 1 rocker shaft bracket
13 Rocker shaft spring
14 Rocker shaft

● **Assembly sequence**

Reverse the order of disassembly.

Service standards

Unit: mm (in.)

Location	Maintenance item	Standard value	Limit	Remedy
2, 14	Rocker bushing-to-rocker shaft clearance [Basic diameter: 24 mm (0.945 in.)]	0.01 to 0.08 (0.000394 to 0.00315)	0.12 (0.00472)	Replace

Tightening torques

Unit: N·m (kgf·m) [lbf·ft]

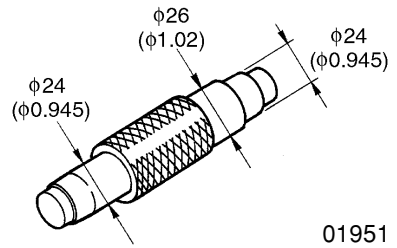
Location	Parts to be tightened	Tightening torque	Remarks
3	Adjusting screw lock nut	34 (3.5) [25.1]	–
7	Rocker shaft set screw	3.9 (0.4) [2.88]	–

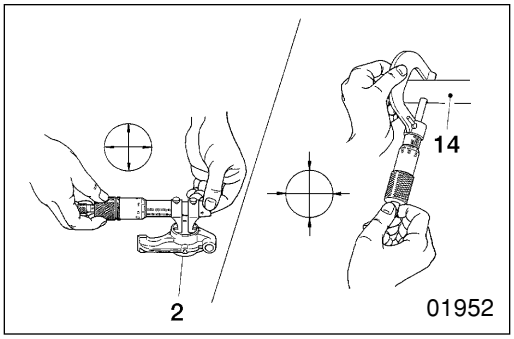
Lubricant

Location	Points of application	Specified lubricant	Quantity
2	Rocker bushing inner surface	Engine oil	As required

Special tools

Unit: mm (in.)

Location	Tool name and shape	Part No.	Application
2	Rocker Bushing Puller 	MH061777	Removing and installing rocker bushings

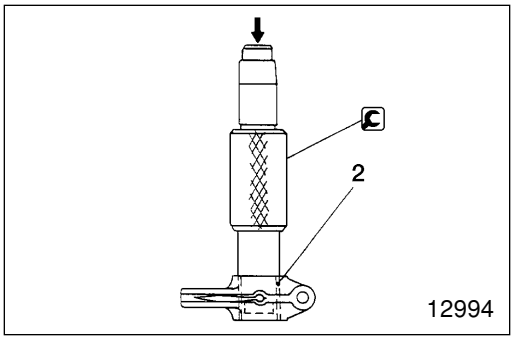


◆ Service procedure

2 14 Rocker bushing and rocker shaft

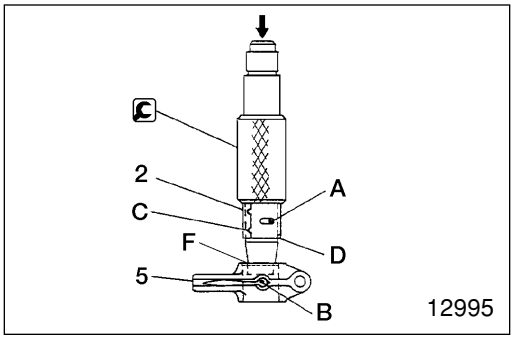
[Inspection]

If any clearance exceeds the specified limit, replace the defective part(s).



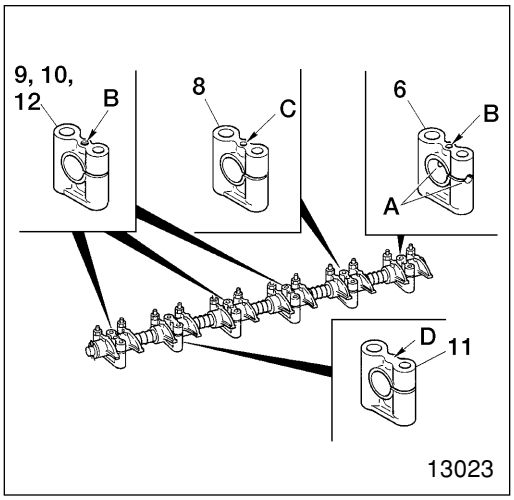
Rocker bushing

[Removal]



[Installation]

- Align the oil hole **A** in the rocker bushing **2** with the oil hole **B** in the rocker **5**.
- Position the notch **C** and seam **D** on the rocker bushing **2** as shown.
- Install the rocker bushing **2** into the rocker **5** from the chamfered side **F**.

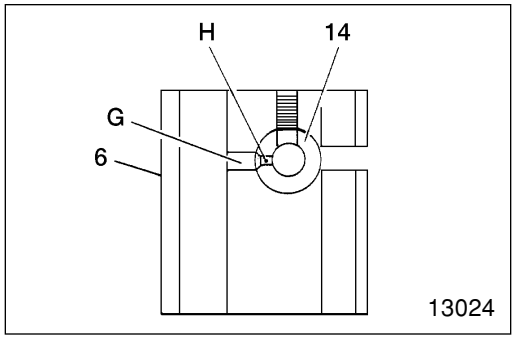


6 8 to 12 14 Installing rocker shaft brackets and rocker shaft

Rocker shaft brackets

Be sure to fit the rocker shaft brackets **6**, **8**, **12** in their correct positions.

A: Oil hole
B: Threaded hole (for M8 rocker cover bolt)
C: Threaded hole (for M6 set screw)
D: No threaded hole



Rocker shaft

Align the oil hole **G** in the No. 6 rocker shaft bracket **6** with the oil hole **H** in the rocker shaft **14**.